

PROJECT PROPOSAL COVER SHEET

WRD REGION:	Western	PROPOSAL NUMBER: AZ-11A
SCIENCE CENTER:	Arizona	DATE (Initial): 01/17/2011
PROJECT TITLE: Coconino County has contacted the U.S. Geological Survey for a geophysical investigation of the Cinder Lake area to determine the depth of the cinder beds and their potential for water storage capacity.		DATE (Revised): 03/31/2011
		PROJECT NUMBER: GC11ZF00EGT0000
SHORT TITLE: Cinder Lake Geophysics		BEGIN DATE: (mo/yr) 02/2011
PROJECT CHIEF: Jamie P. Macy		END DATE: (mo/yr) 09/2012

Choose one: ☒ **RESEARCH** ☐ **RESOURCE APPRAISAL**

DISCIPLINE: ground-water quantity 98 %, surface-water quantity %, ground-water quality 2 %,

PUBLICATION TYPE:

Scientific Investigative

Report (SIR): X

Journal Article:

Abstract:

Open File Report

(OFR):

Letter:

Poster:

Fact Sheet:

Professional Paper:

Other (specify)

Data Series:

Book Chapter:

ESTIMATED PROJECT FUNDING

Choose one: ☒ **firm** ☐ **probable** ☐ **questionable**

CUSTOMER NAMES(S)/NUMBER(S): Coconino County and U.S. Forest Service

FISCAL YEAR	2011	2012	
OFA/FEDERAL	\$ 26,000	\$	
COOP REPAY	\$	\$	
COOP DIRECT	\$ 7,000	\$ 13,000	
COOP UNMATCHED	\$ 57,250	\$ 750	
COOP TOTAL	\$	\$	
FMFs:	\$ 7,000	\$ 13,000	
TOTAL FOR FY:	\$ 97,250	\$ 26,750	

REMARKS:

AUTHOR:	Jamie P. Macy	May 10, 2011
AzWSC ENDORSEMENT:	James Leenhouts	, 2011
REGIONAL ENDORSEMENT:		, 2011
APPROVED BY:		, 2011

SUMMARY

Title: Coconino County Cinder Lake depth of cinders geophysical investigation

Cooperating Agency: Coconino County, AZ and U.S. Forest Service

Project Chief: Jamie P. Macy

Problem: The 2010 Schultz fire northeast of Flagstaff, Arizona burned over 14,000 acres on the east side of the San Francisco Mountain from June 20 to July 3. As a result, several drainages in the burn area are now more susceptible to runoff and flooding events of greater frequency and volume. Massive damage to private lands and residences, municipal water lines, and roads in and down-gradient of the burn areas have occurred, and greater than expected flooding continues to persist. Coconino County, which encompasses Flagstaff, has responded by deepening and expanding a system of roadside channels to move flood water away from communities and into open Forest Service lands, called Cinder Lake, where rapid infiltration can occur. Water that has been channeled into the Cinder Lake area is currently infiltrating into the volcanic cinders and could eventually migrate to the deep regional groundwater flow system that underlies the area. Very little is known about the depth of cinder beds in the Cinder Lake area or their potential water storage capacity. Coconino County has contacted the U.S. Geological Survey for a geophysical investigation of the Cinder Lake area to determine the depth of the cinder beds and their potential for water storage capacity.

Objectives: The objective of this study is to determine the depth of cinders to basalt in the Cinder Lake area for potential water storage of runoff from the Schultz Fire burn area in northeast Flagstaff, AZ.

Approach: Geophysical surveys and two boreholes drilled for monitoring wells will be used to assess the depth of cinders to basalt. Surface geophysics are non-intrusive methods that can indicate changes in electrical properties and characteristics of the subsurface. Two boreholes will be used to calibrate the geophysical tools and the boreholes will be cased as monitoring wells to monitor for the possible presence of water during infiltration events. A set of funds will be set aside as contingency funds for the possibility that the first geophysical technique doesn't prove effective, in which case, a second technique would be used. The contingency funds will also be available for water-quality sampling should either of the boreholes come in contact with a perched water layer. The regional groundwater system is located 1,200 to 1,400 ft below the Cinder Lake area and groundwater in the boreholes would only be expected from a perched water layer. In addition to the original work plan, the Arizona Water Science Center (AZWSC) has agreed to contribute Cooperative funds that will be used for gravity measurements and the publishing of an on-line USGS report. Gravity measurements will be used to address the question of whether infiltration is moving vertically to the regional groundwater system, moving vertically, but remaining in the local system, or moving horizontally in the local system.

Products: The products of this investigation will include a USGS Scientific Investigation Series report. Periodic meetings or conference calls will be arranged with Coconino County personnel to discuss the progress and results prior to publication of the report.

Relevance and Benefits: Information and knowledge gained from this proposed project will provide information to Coconino County that will aid the County in determining the best areas to divert and store runoff from a fire damaged area.

A proposal to address the depth of cinders in the Cinder Lake area, Flagstaff, AZ

Prepared by the U.S. Geological Survey, Arizona Water Science Center

Background

The 2010 Schultz fire northeast of Flagstaff, Arizona burned over 14,000 acres on the east side of the San Francisco Mountain from June 20 to July 3 (fig. 1). As a result, several drainages in the burn area are now more susceptible to runoff and flooding events of greater frequency and volume. Despite a rapid response from the U.S. Forest Service (USFS) to mitigate some of the expected flooding and debris effects of the fire, July 20, 2010 saw one of the largest flood events associated with the Schultz Fire burn area. Massive damage to private lands and residences, municipal water lines, and roads in and down-gradient of the burn areas have occurred, and greater than expected flooding continues to persist. Although the fire occurred on lands of the USFS, there are a number of subdivisions located on unincorporated lands in Coconino County within drainage basins down-gradient of the burn area, including the communities of Timberline, Girls Ranch, Pine Estates, and Wupatki Trails.

The County has responded by deepening and expanding a system of roadside channels to move flood water away from these communities and into open Forest Service lands where rapid infiltration can occur. The Copeland and Campbell Channels were designed to safely reroute the runoff from two of the largest drainages originating in the burn area through developed lands and distribute the water into the Cinder Lake area (fig. 1). The Copeland and Campbell channels are designed to carry about 1,600 and 1,200 cubic feet per second (ft³/s) of water, respectively.

Cinder Lake is a dry, cinder bed located on Forest Service land surrounded by cinder cones to the north, east, and south, and the alluvial fans at the base of San Francisco Mountain to the west. Water that has been channeled into the Cinder Lake area infiltrates into the volcanic cinders and could follow 3 flowpaths out of the Cinder Lake area including, recharging the deep regional groundwater flow system that underlies the area, recharging the Rio de Flag through the subsurface by moving laterally along confining layers such as basalt, or accumulating enough in the subsurface to the point where Cinder Lake fills with water and surface runoff flows to the Rio de Flag out of the area to the southeast. Very little is known about the depth of cinder beds in the Cinder Lake area or their potential water storage capacity. Coconino County is interested in determining the water-storage capacity of the cinder deposits in the Cinder Lake area for distributing and infiltrating water from flow events associated with the Schultz Fire burn area. The amount of water that can be accommodated in the cinders during a given time interval is a function of not only the volume of available storage (capacity) in the cinder deposits, but also the volume of groundwater inflow and outflow. Water-storage capacity for this study refers to the total available water storage in the cinders and does not take into consideration the volume of inflow and outflow of the system. If the water being stored in the cinder beds rises close to land surface, then there is also concern for the impacts to an unlined City of Flagstaff landfill just to the south.

advancing the knowledge of a regional hydrologic system and advancing field or analytical methods (Hirsch, 2004; U.S. Geological Survey, 2007).

Objective

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Approach

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1. Geophysical Surveys in and around Cinder Lake – Transient Electromagnetics (TEM) will be used to identify the depth of cinders to the first basalt flow (and possibly deeper interbeds of cinders and basalt). Two TEM transects will be surveyed in the Cinder Lake area. Additional single sounding TEM surveys will be conducted around Cinder Lake and in the vicinity of the City of Flagstaff Landfill.

2. Monitoring Wells - 2 boreholes will be contracted or drilled by the USGS using appropriate equipment and methods for the collection of core and cuttings to help calibrate the geophysical surveys. Should there be water present in the boreholes, they will be cased and completed as monitoring wells for water-level measurements and the collection of water samples that can be used to address water-quantity and water-quality issues. Water-level measurements will address the issue of what level of water is held in the lake after runoff events because the wells will provide physical measurements of the level of the water in the lake. Water-quality samples will help to address the question of what kind of water was in Cinder Lake before 2011 runoff events and how old is that water. Water-level measurements and water-quality samples will be collected in accordance with USGS protocols and follow the USGS National Field Manual (U.S. Geological Survey, variously dated). The boreholes in the Cinder Lake area will be drilled to a depth of 200' or until the first basalt flow is reached, whichever occurs first.

3. Contingency – If the TEM method does not work due to unanticipated electrical properties of the subsurface material, other geophysical tools will be explored such as controlled source audio magnetotellurics, seismic refraction, or ground penetrating radar. Also, if water is found in the drilled boreholes, these contingency funds could be used to process water samples that will be collected for field parameters, major ions, trace elements, nutrients, carbon-14, tritium, and chlorofluorocarbons. Field parameters that will be collected include pH, conductivity, temperature, dissolved oxygen, and alkalinity. Major ions, trace elements and nutrient concentration are collected to provide a chemical composition and characterization of the sampled water which can help identify the water found in Cinder Lake when compared to runoff. Carbon-14, tritium, and chlorofluorocarbons data will provide information about the age of the water in Cinder Lake to determine if water in the perched water bearing zone is recent or older. All water-quality data will be archived in QWDATA, and a replicate sample will be taken for quality-assurance purposes.

4. USGS Cooperative Water Program Support — USGS cooperative matching funds will be contributed for additional support to the geophysical investigation including gravity measurements and report publication. USGS funds will be used to explore the use of gravity as an indicator of groundwater storage change in the subsurface, and to publish a written report describing the methods and results of the geophysical investigation. Gravity measurements will be used to explore whether infiltration is moving vertically, presumably to the regional groundwater system, or horizontally into other local perched water-bearing zones. A USGS on-line report will be published at the end of Fiscal Year 2012.

Products and Deliverables

All data collected and produced for this study will be archived in accordance with the AZWSC's archiving policy, will be available at the cooperator's request and available to the public when published as a USGS Scientific Investigations Report. Water-level data and water-quality data will be stored and is accessible through NWIS. Wells will be inventoried and entered into GWSI. A final report describing the methods and results of the study will be published as a web-only USGS Scientific Investigations Report, following completion of data analysis and collection. Periodic meetings or conference calls will be arranged with Coconino County personnel to discuss the progress and results prior to publication of the report.

References

Hirsch, Robert M., 2004, Avoid Competition with the Private Sector: U.S. Geological Survey Water Resources Discipline Policy Memorandum No. 04.01, 3 p.

U.S. Geological Survey, 2007, Facing tomorrow's challenges—U.S. Geological Survey science in the decade 2007–2017: U.S. Geological Survey Circular 1309, x + 70 p.

U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1-A9, available online at <http://pubs.water.usgs.gov/twri9A>.